

Claims

1. A method of forming in a ceramic substrate a scribe line that facilitates breakage of the ceramic substrate into separate pieces having side margins defined by the scribe line, the ceramic substrate having a thickness and a surface on which is formed a pattern of multiple nominally identical, mutually spaced apart electronic components, the electronic components separated by streets along which the scribe line is formed such that the separate pieces created by breakage of the ceramic substrate comprise separate circuit components, the method comprising:

aligning an ultraviolet laser beam characterized by an energy and a spot size with one of the streets on the surface of the ceramic substrate;

imparting relative motion between the ultraviolet laser beam and the ceramic substrate such that the laser beam is directed lengthwise along the street and effects depthwise removal of ceramic substrate material to form a shallow trench, the energy and spot size of the ultraviolet laser beam effecting the depthwise removal in the absence of appreciable melting of the ceramic substrate material so that the trench formed in the ceramic substrate material has a width that converges from the surface to a trench bottom in the form of a sharp snap line; and

the shape of the trench forming a region of high stress concentration extending into the thickness of the ceramic substrate and along the snap line so that, in response to a breakage force applied to either side of the trench, multiple depthwise fractures propagate into the thickness of the ceramic substrate in the region of high stress concentration to effect clean breakage of the ceramic substrate into separate circuit components having side margins defined by the snap line.

2. The method of claim 1, in which the electronic components are selected from the group consisting essentially of resistors and capacitors.

3. The method of claim 1, in which a cross-section of the trench is of generally triangular-shape.

4. The method of claim 1, in which the laser beam has a sufficiently short wavelength and a pulse energy that cooperate to minimize resolidification of the ceramic substrate along the sidewalls of the trench.

5. The method of claim 1, in which the snap line is formed at a depth that does not appreciably penetrate the ceramic substrate thickness, thereby minimizing the formation of microcracks extending perpendicular to the scribe line formed in the ceramic substrate piece.

6. The method of claim 5, in which the depth is between about 5% and about 25% of the ceramic substrate thickness.

7. The method of claim 1, in which the laser beam has a wavelength of less than about 400 nm.

8. The method of claim 1, in which multiple scribe lines are formed in the ceramic substrate.

9. The method of claim 1, in which the laser beam has an energy per pulse of between about 50 uJ and about 1000 uJ.

10. The method of claim 1, in which the scribe line is formed by a single pass of the laser beam.

11. The method of claim 1, in which the scribe line is formed by multiple passes of the laser beam.

12. The method of claim 1, in which the laser beam is emitted by a laser operating at a repetition rate of between about 15 kHz and about 100 kHz.

13. The method of claim 1, in which the laser beam is emitted by a laser operating at a power of between about 0.5 W and about 10 W.

14. The method of claim 1, in which the trench has a width that is less than about 30 microns.

15. The method of claim 1, in which the ceramic substrate has an upper surface and a lower surface and one of the upper and lower surfaces is at least partly coated with a layer of metal.

16. The method of claim 15, in which the metal layer is copper.

17. The method of claim 1, in which the ceramic substrate has an upper surface and a lower surface and one of upper and lower surfaces has printed

on it a pattern that facilitates the alignment of the street and the ultraviolet laser beam as it moves lengthwise down the street.

18. The method of claim 1, in which the ceramic substrate includes first and second opposing side margins, and in which the streets intersect the first and second opposing margins at oblique angles.

19. The method of claim 18, in which the ceramic substrate is of generally rectangular shape.

20. The method of claim 1, in which at least one of the streets includes a metal layer.